

Overview of Ohio SARS-CoV-2 Wastewater Monitoring System

Presented to Northeast Ohio Areawide Coordinating Agency
Wastewater Designated Management Agency Meeting

November 4, 2020

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Zuzana Bohrerova, *Ohio Water Resources Center*
Rebecca Fugitt, *Ohio Department of Health*



Jay Garland | Contact: Garland.Jay@epa.gov

Jay Garland is a Senior Scientist in ORD's Center for Environmental Solutions and Emergency Response and has worked in federal service for almost 30 years. Jay has worked on a range of topics, including methods for microbial community analysis, factors affecting survival of human associated pathogens, and various biological approaches for recycling wastes. His current efforts focus on advancing innovative approaches to water infrastructure, including mitigating risks associated with antimicrobial resistance in the water cycle.



Research Team

EPA-ORD:

Nichole Brinkman, Jay Garland, Michael Jahne, Scott Keely, Maitreyi Nagarkar, Emily Wheaton, and Eunice Varughese

Cincinnati Metropolitan Sewer District:

Bruce Smith, John Barton, and Mary Lynn Lodor

Hamilton County Public Health Department:

Chris Griffith

State of Ohio

- **Ohio Department of Health:** Rebecca Fugitt
- **Ohio EPA:** Brian Hall and Tiffani Kavalec

Ohio Water Resource Center: Zuzana Bohrerova

Participating Utilities Across the State

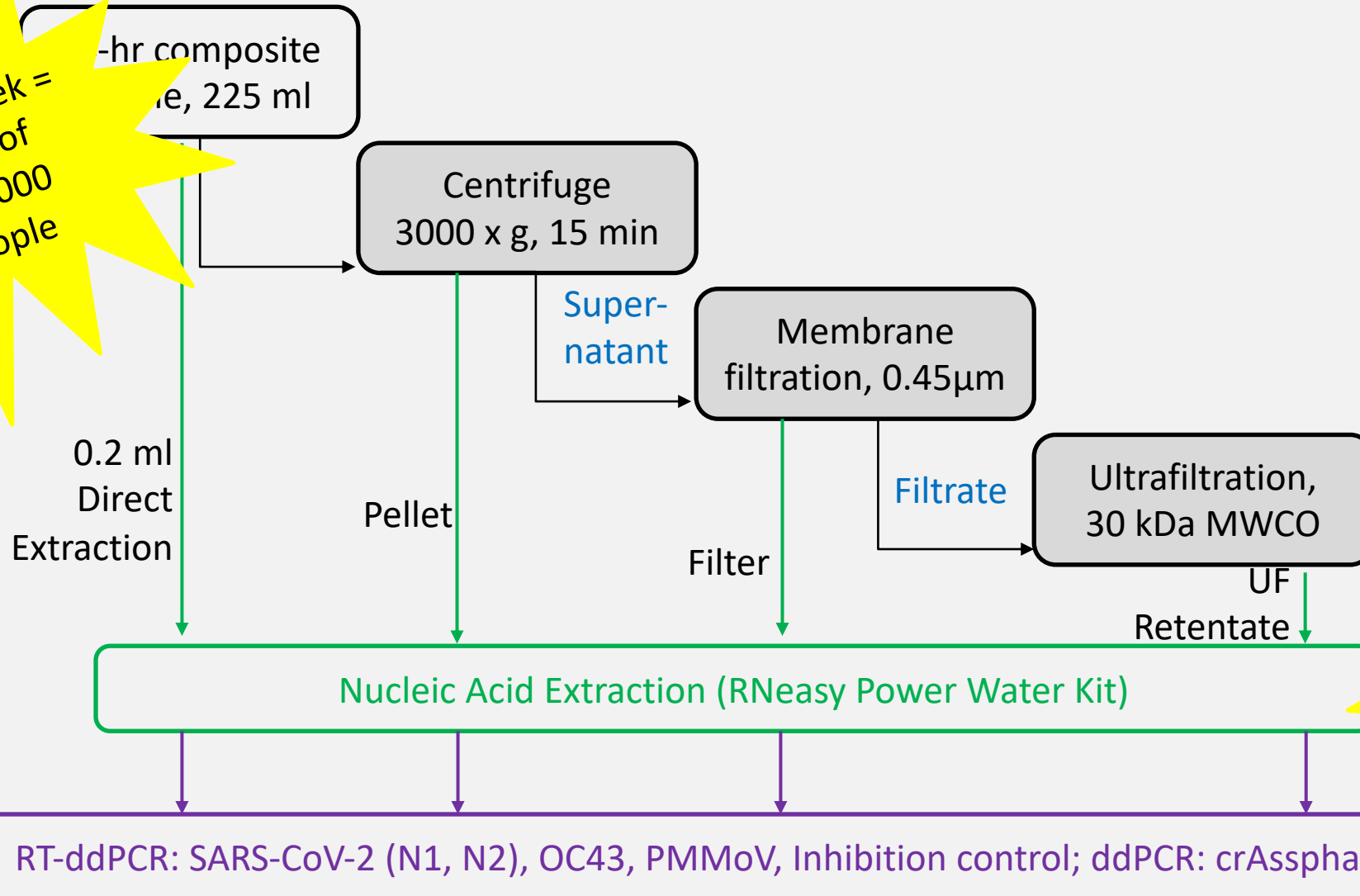


Outline for Presentation

- *Analytical method development*
- Understanding dilution and degradation in the sewer
- Relating the sewer signal to community case rates
- *Building a statewide network of sampling*
- *Translating the information into public health decisions*

Sample Processing and Analysis

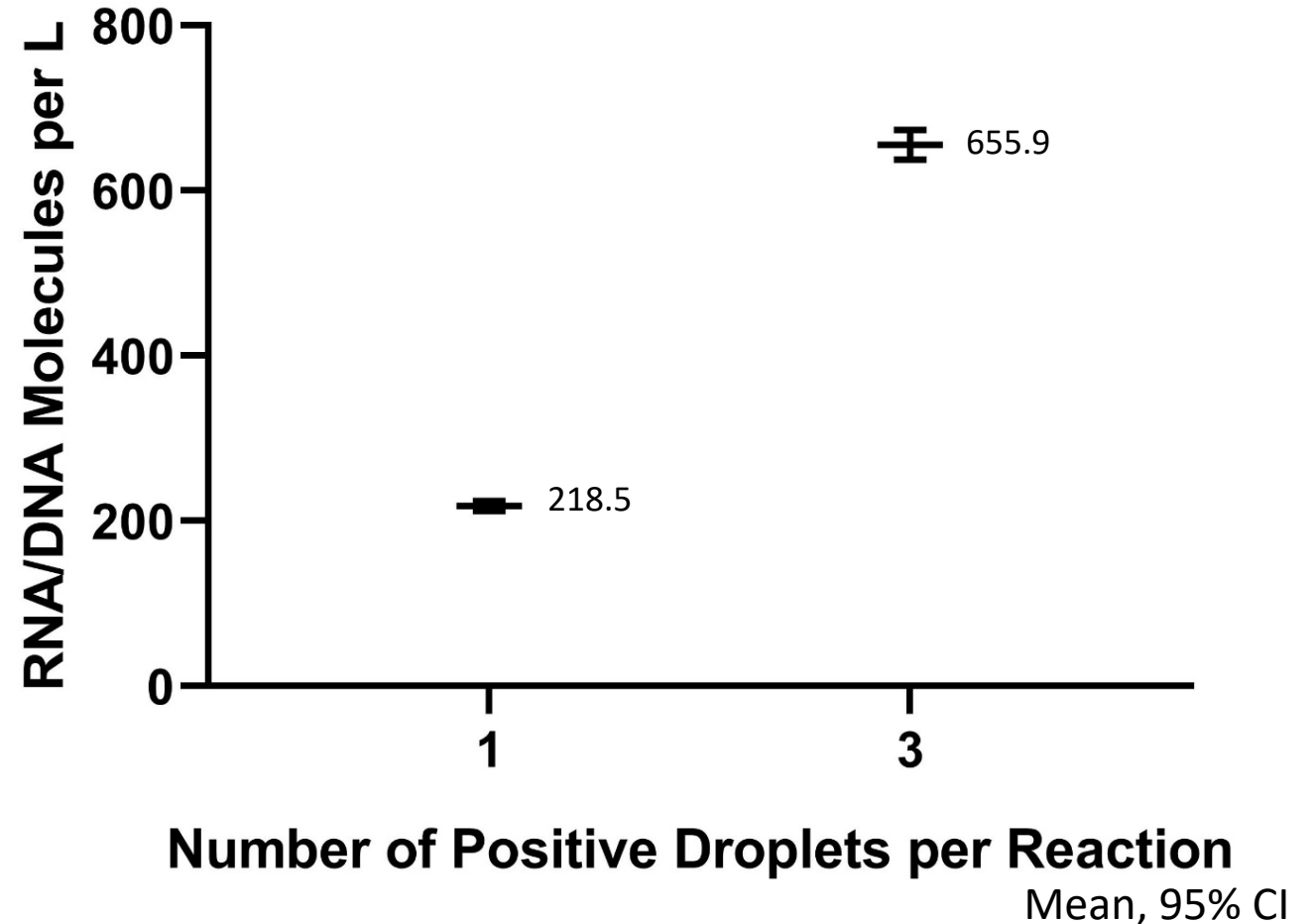
Mill Creek =
pool of
488,000
people



Turnaround
time = 3
days

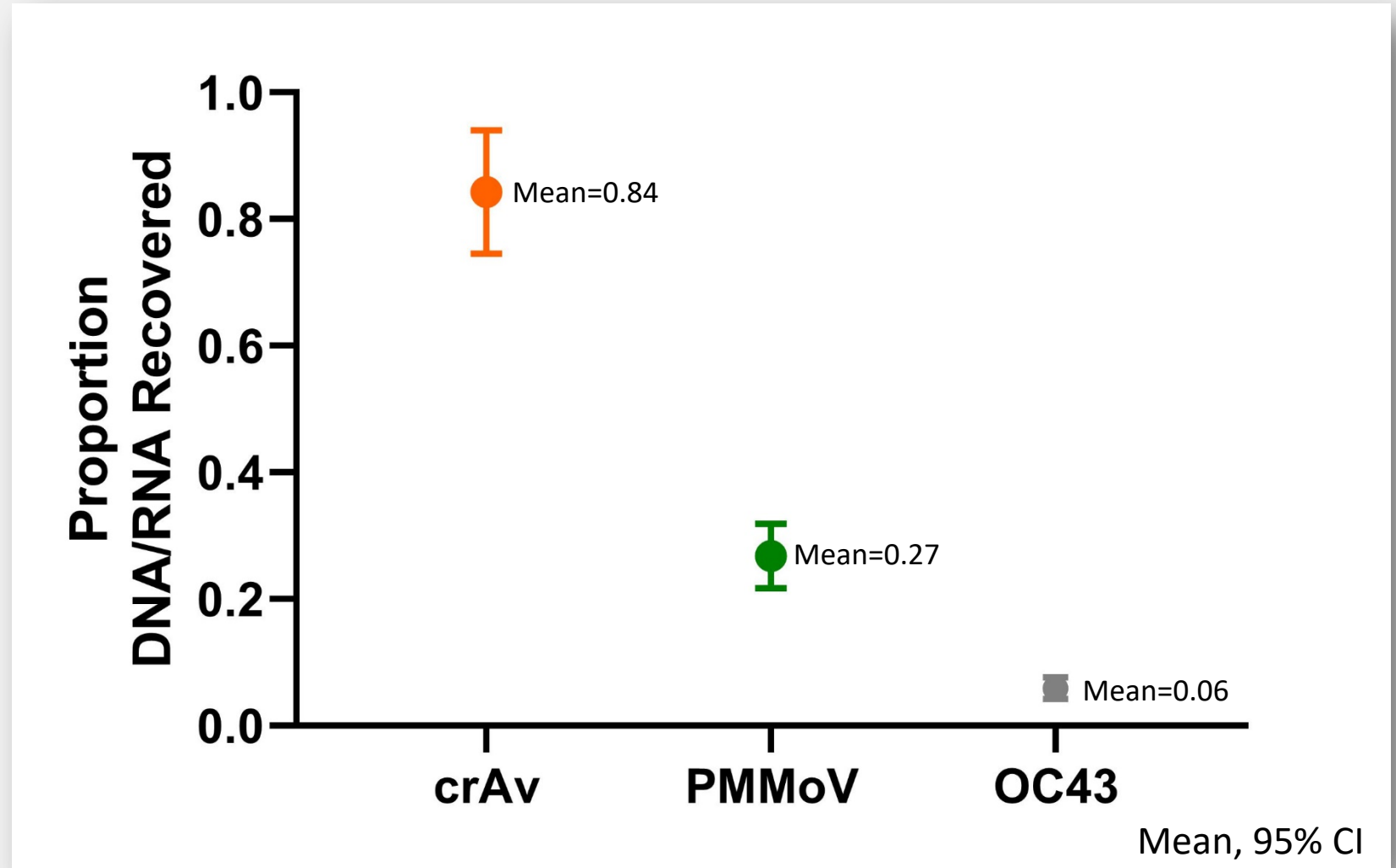
Limits of Detection/Quantification

- Volume of sample processed
- Concentration factor
- Volume of processed sample analyzed
- Analytical sensitivity (i.e., minimum detectable concentration)
- Ideal conditions
- Practical limits likely higher due to losses during processing



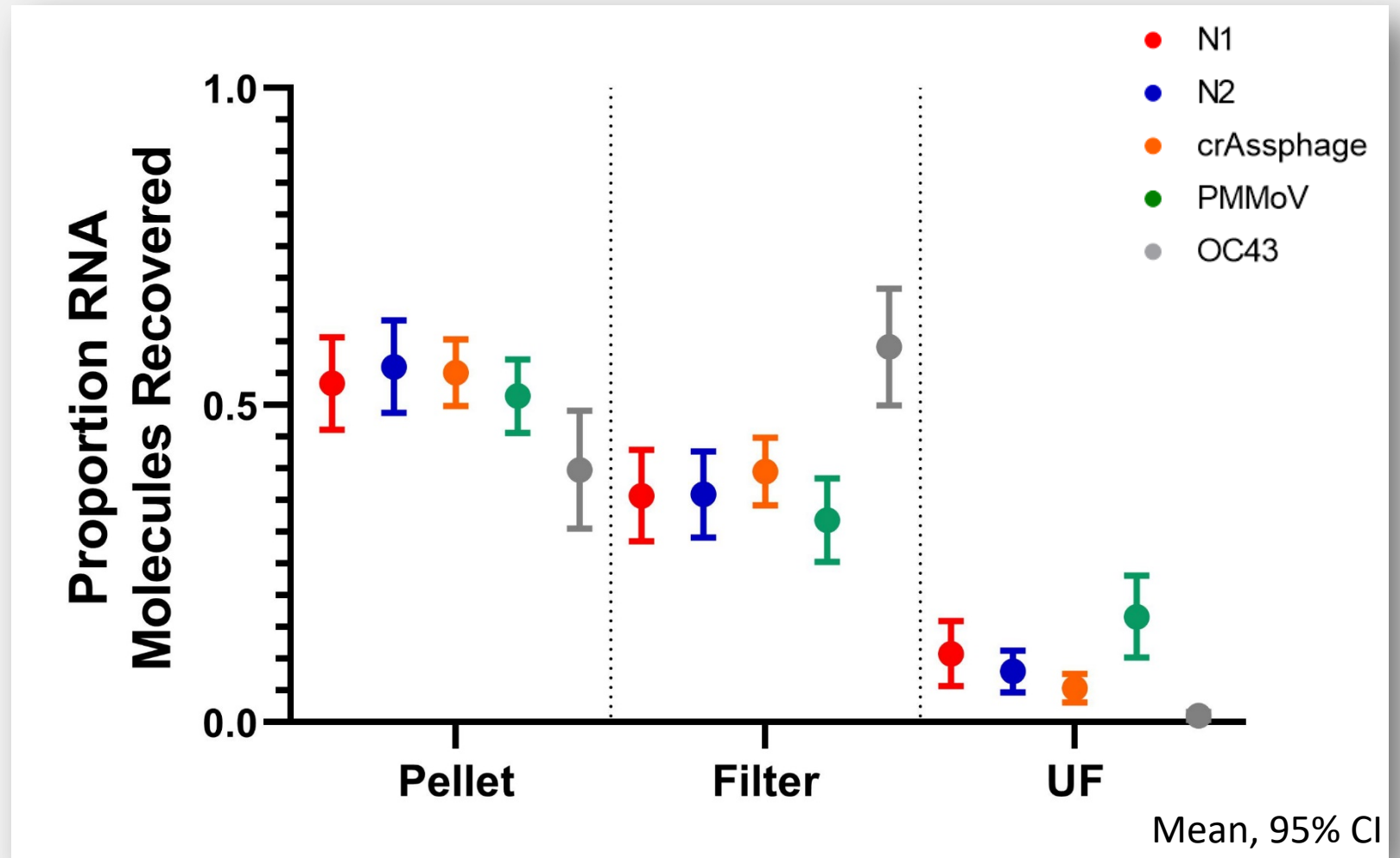
Recovery Efficiency of Endogenous and Spiked Virus

- Endogenous virus
 - crAssphage
 - Pepper Mild Mottle Virus
- Spiked virus
 - OC43
- Measure concentrations before and after sample processing



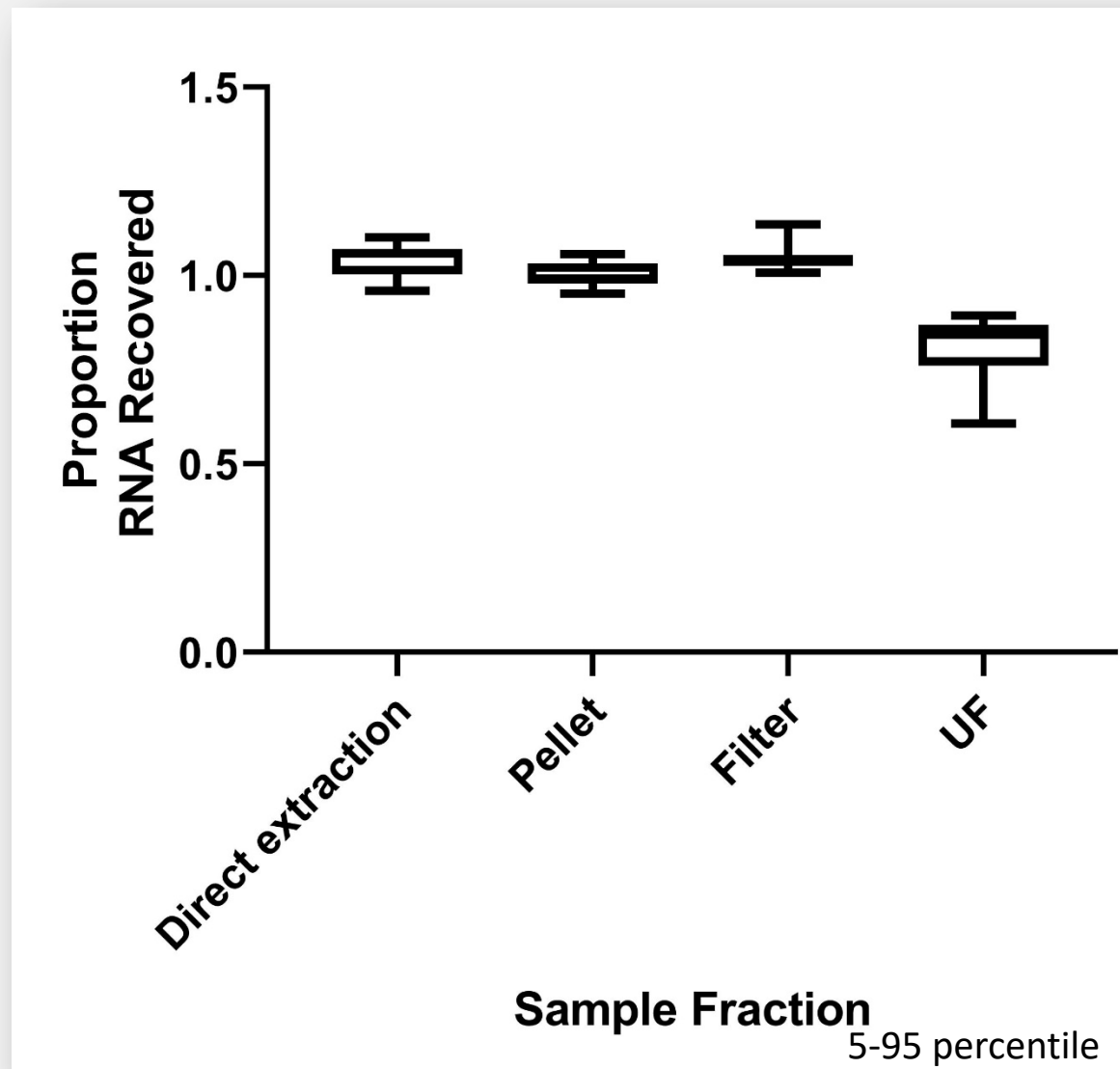
Partitioning of Virus in Sample Fractions

- Where are viruses recovered within samples?
- Proportion of total virus measured in each sample fraction
- ~ 90% measurable virus in pellet and filter fractions

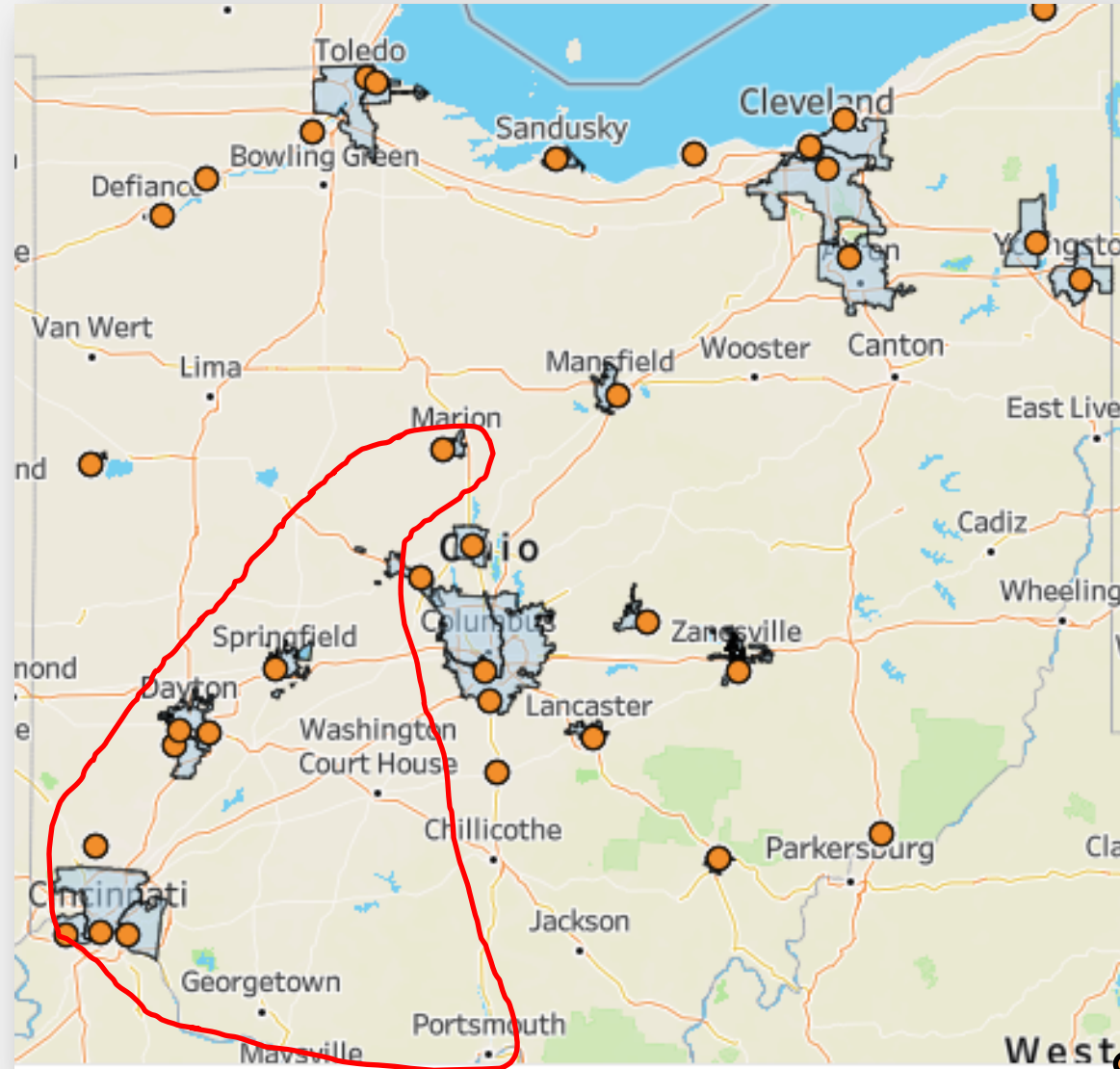


RT-ddPCR Inhibition

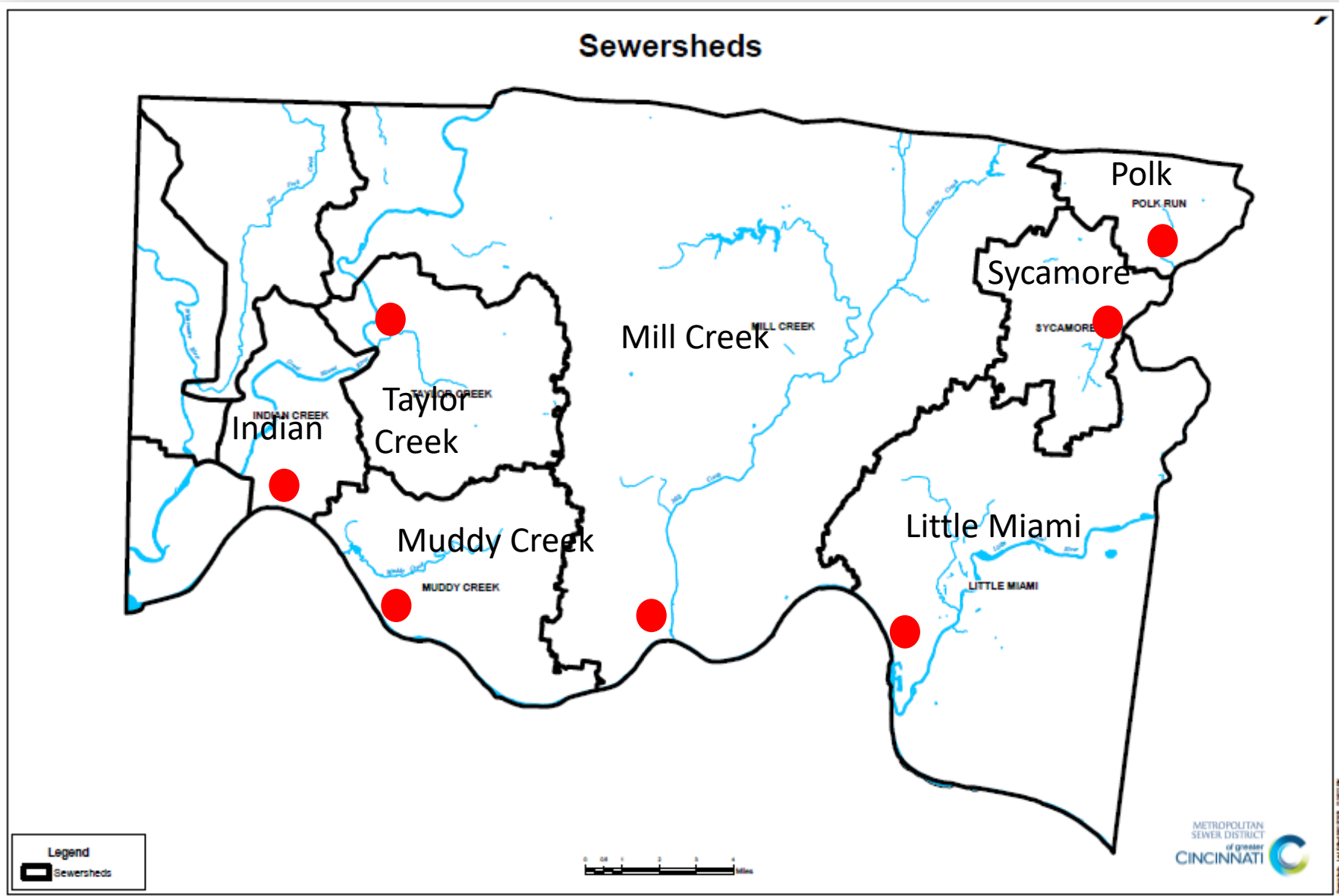
- Add RNA before RT-ddPCR
- Compare RNA concentration in sewage sample extracts and matrix-free controls
- Minimal RT-ddPCR inhibition observed



Weekly Wastewater Monitoring

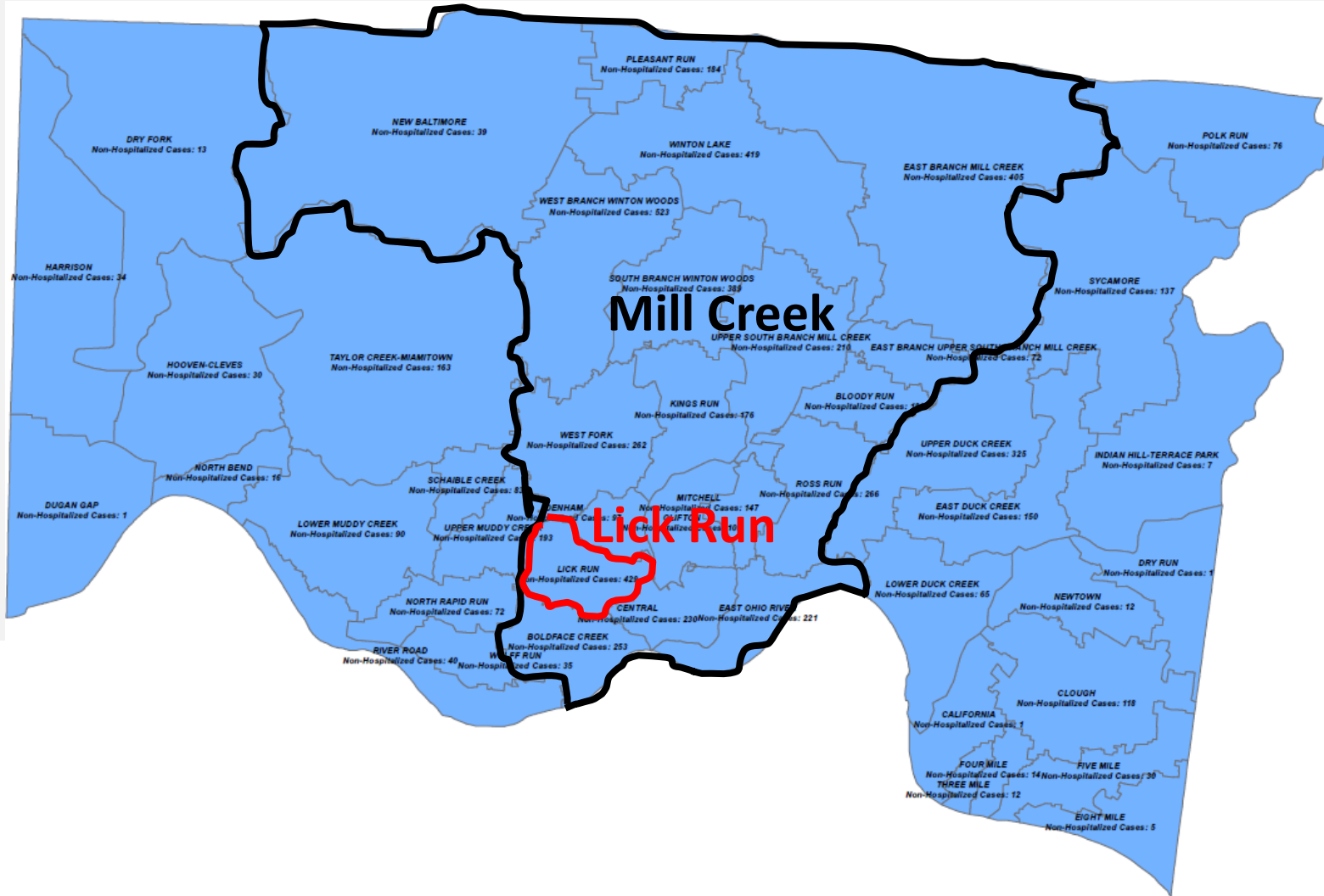


Cincinnati Metropolitan Sewer District



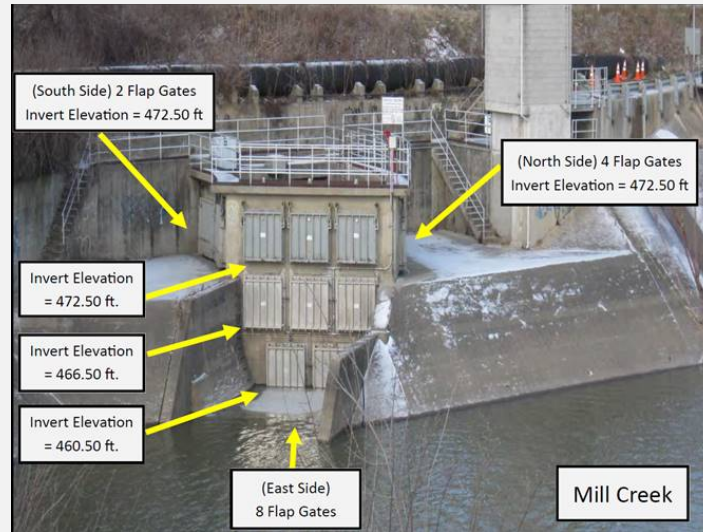
 Average Age		% Industrial	% Combined	Dilution
	Mill Creek (118 MGD)	5.0	40	0.5:1
	Little Miami (37 MGD)	4.2	30	0.4:1
	Muddy Creek (14 MGD)	<0.05	30	0.5:1
	Sycamore Creek (8 MGD)	1.1	0	0.5:1
	Polk Run (5 MGD)	<0.1	0	0.8:1
	Indian Creek (1 MGD)	0	0	1:1
	Taylor Creek (3 MGD)	0	0	1.8:1

Sub-Sewershed Sampling



Sub-Sewershed Sampling – Lick Run

Combined
Sewer
Overflow



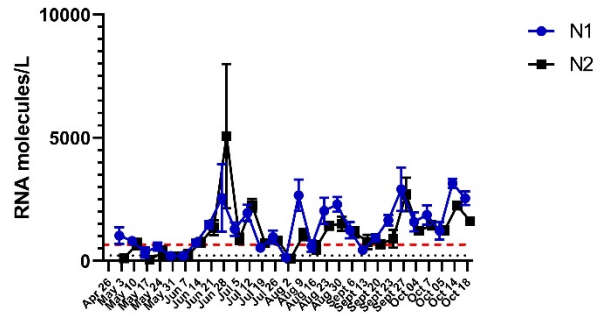
Remote Composite Sampler
~10L between 8-11 am
~500 ml every 15 min



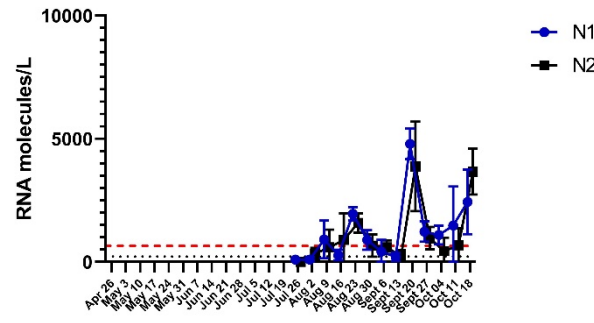


Temporal Trends of SARS-CoV-2 in Sewersheds

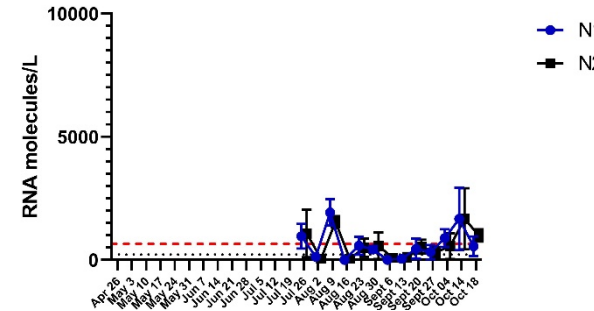
Mill Creek



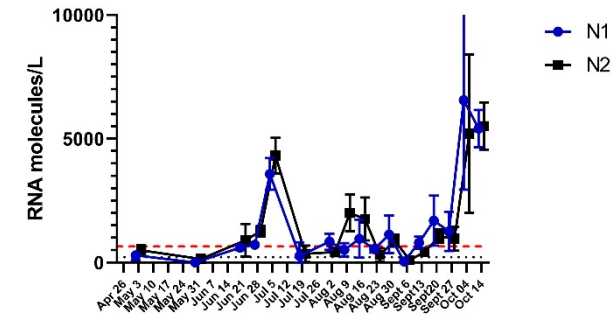
Little Miami



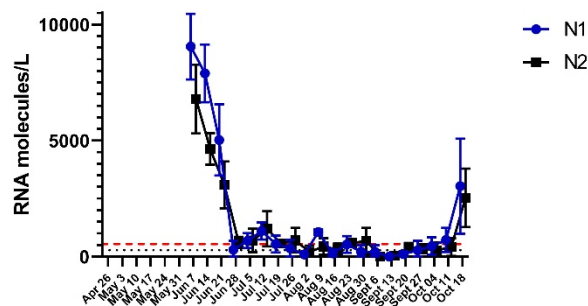
Muddy Creek



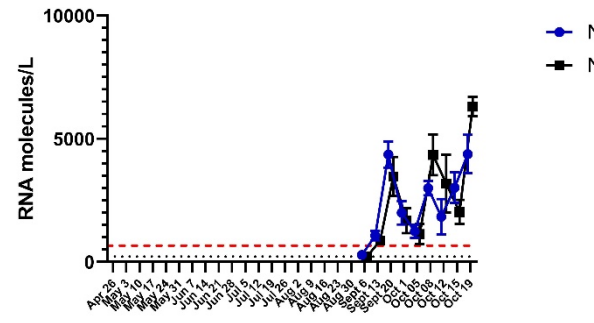
Taylor Creek



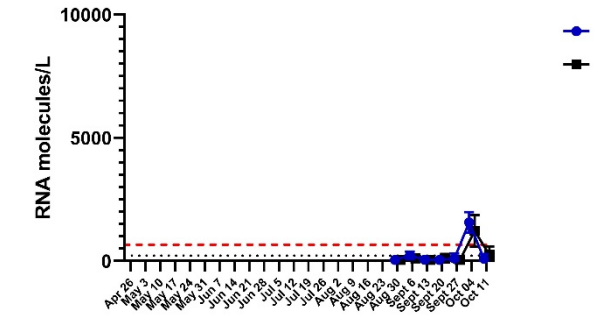
Lick Run



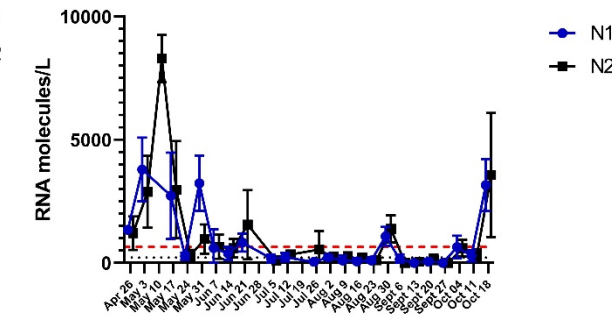
Hamilton



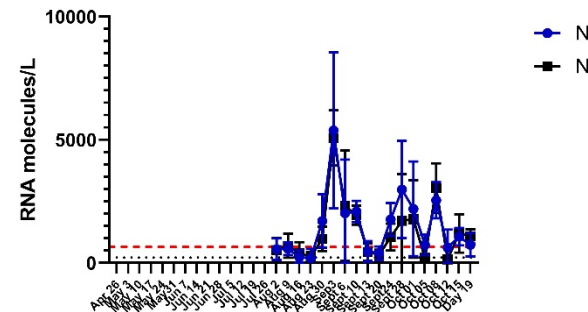
Portsmouth



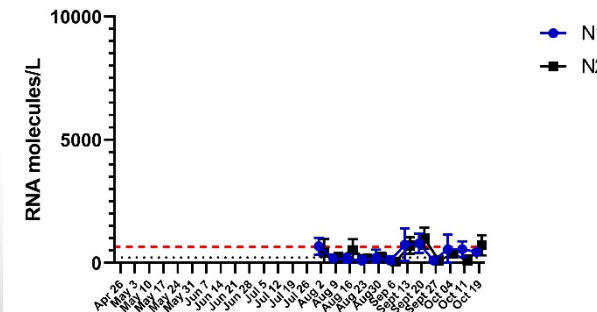
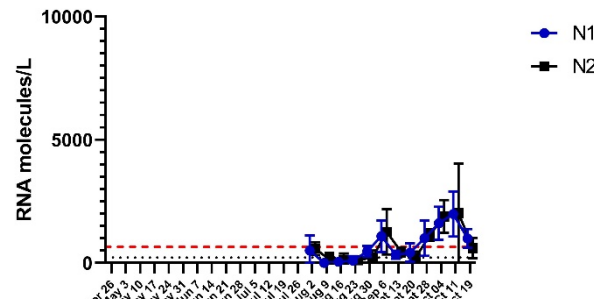
Marion



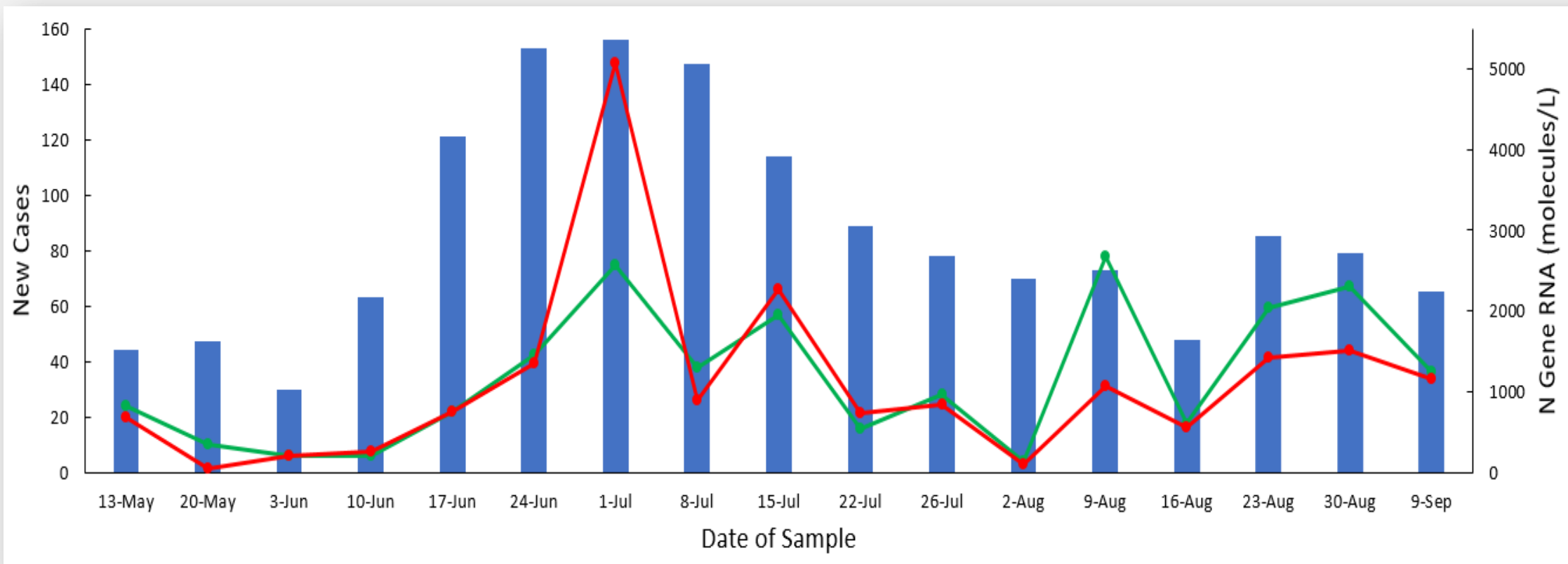
Dayton



Western Regional

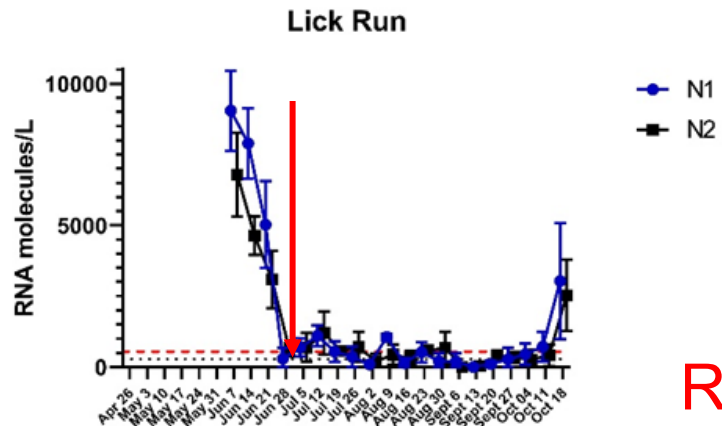
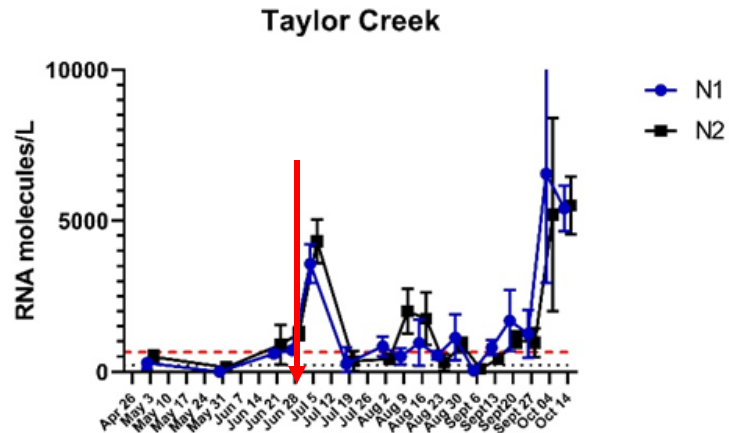
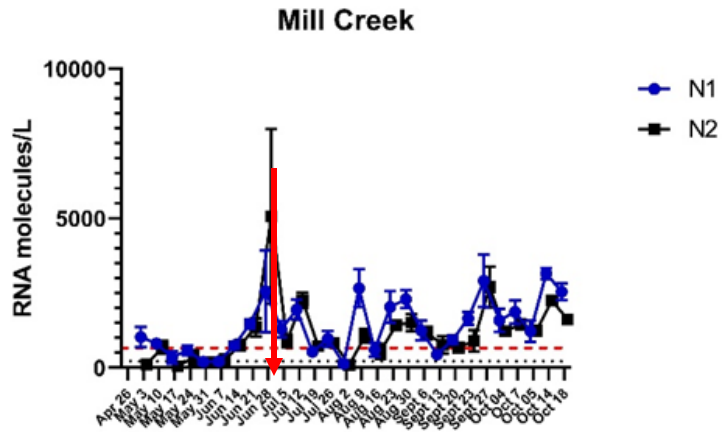


SARS-CoV-2 RNA and New COVID-19 Cases



N1 7-day case averages for Hamilton County centered around the sample collection date

N2 RNA data from Mill Creek Sewershed, serves 488,000 individuals
Flow of 118 Million Gallons Per Day (MGD); relative to 186 MGD for entire county

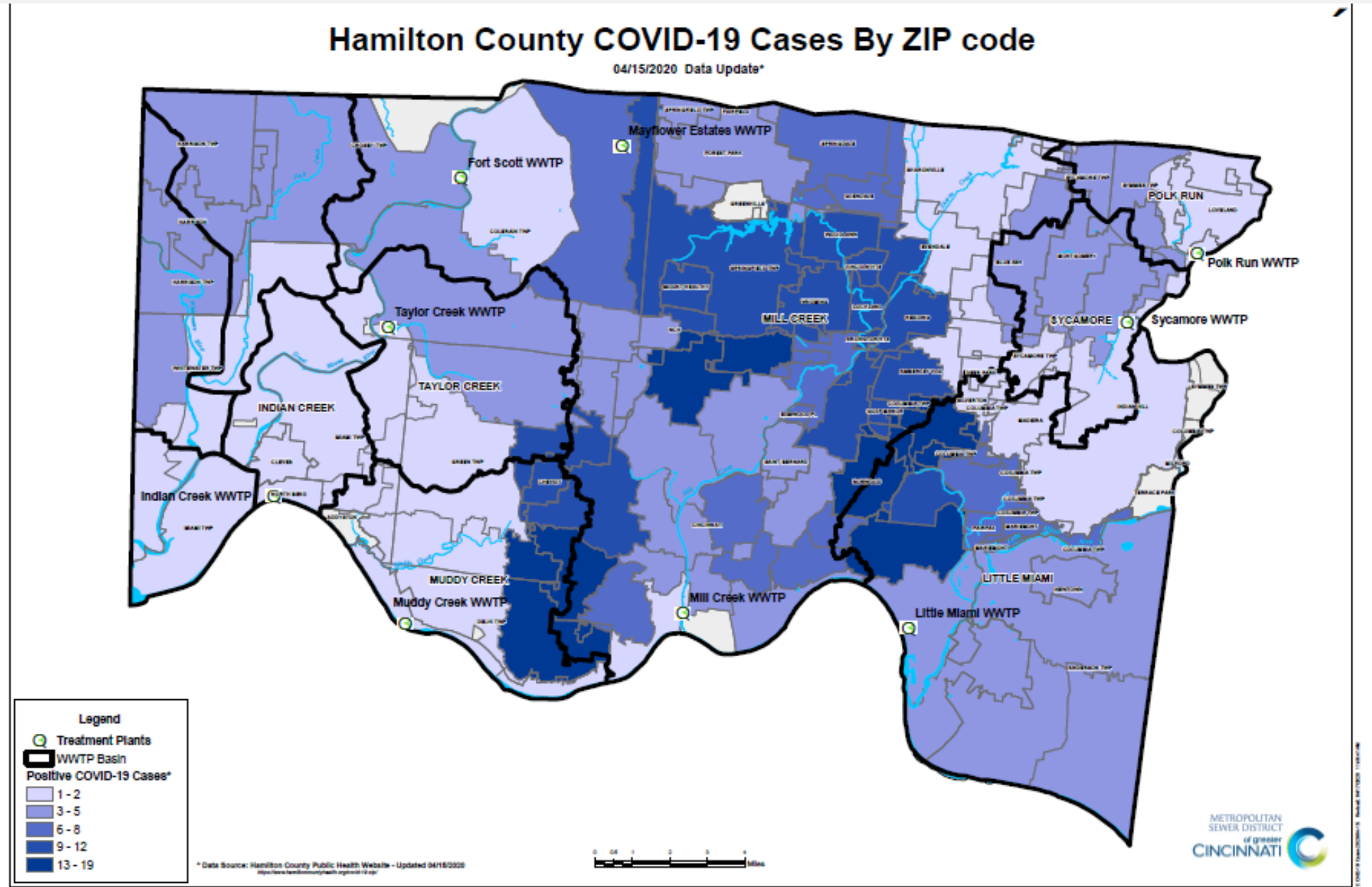


Different Views of Community Infection

Red Line – County Infection Peak in early July ¹⁷

Next Steps:

Relating
Sewer Signal
not to Zip
codes or
County
Infections
Rates





Conclusions/Next Steps

Analytical Method Development

- Defined method with estimates of recovery and inhibition (improved recovery a priority)
- Most virus is observed with solids fractions of wastewater influent samples

Dilution/Degradation in the Sewer

- On-going modeling efforts to evaluate different normalization approaches (flow rate, fecal strength estimates)
- Comparisons between sewersheds with distinctive industrial and stormwater inputs on-going

Relating the Sewer Signal to Infection Rates

- Local county COVID-19 cases peaked in late June-early July and SARS-CoV-2 in Mill Creek wastewater followed this trend
- Developing models to account for factors influencing virus detection, using sewershed specific infection rates



Zuzana Bohrerova | Contact: Bohrerova.1@osu.edu

Zuzana Bohrerova serves as a Research Specialist in the Department of Civil, Environmental and Geodetic Engineering at OSU and as the Associate Director of the Ohio Water Resources Center (WRC). She got her Masters of Public Health at the Ohio State University, Masters and PhD at the Mendel University in agricultural engineering and post doctorate at Duke University in environmental engineering. In addition to research, she teaches and participates in variety of outreach and educational events in the state, focusing on water treatment.



May
2020

Governor DeWine initiates
wastewater SARS-CoV-2 monitoring
project



June
2020

Ohio EPA - \$2,000,000 for wastewater
monitoring project via CARES funds
ODH is project lead
Ohio WRC project coordinator



Monitoring and Analyzing
July 2020

- 7 large cities
- 15 locations sampled
- 3 laboratories – OSU, UT, US EPA



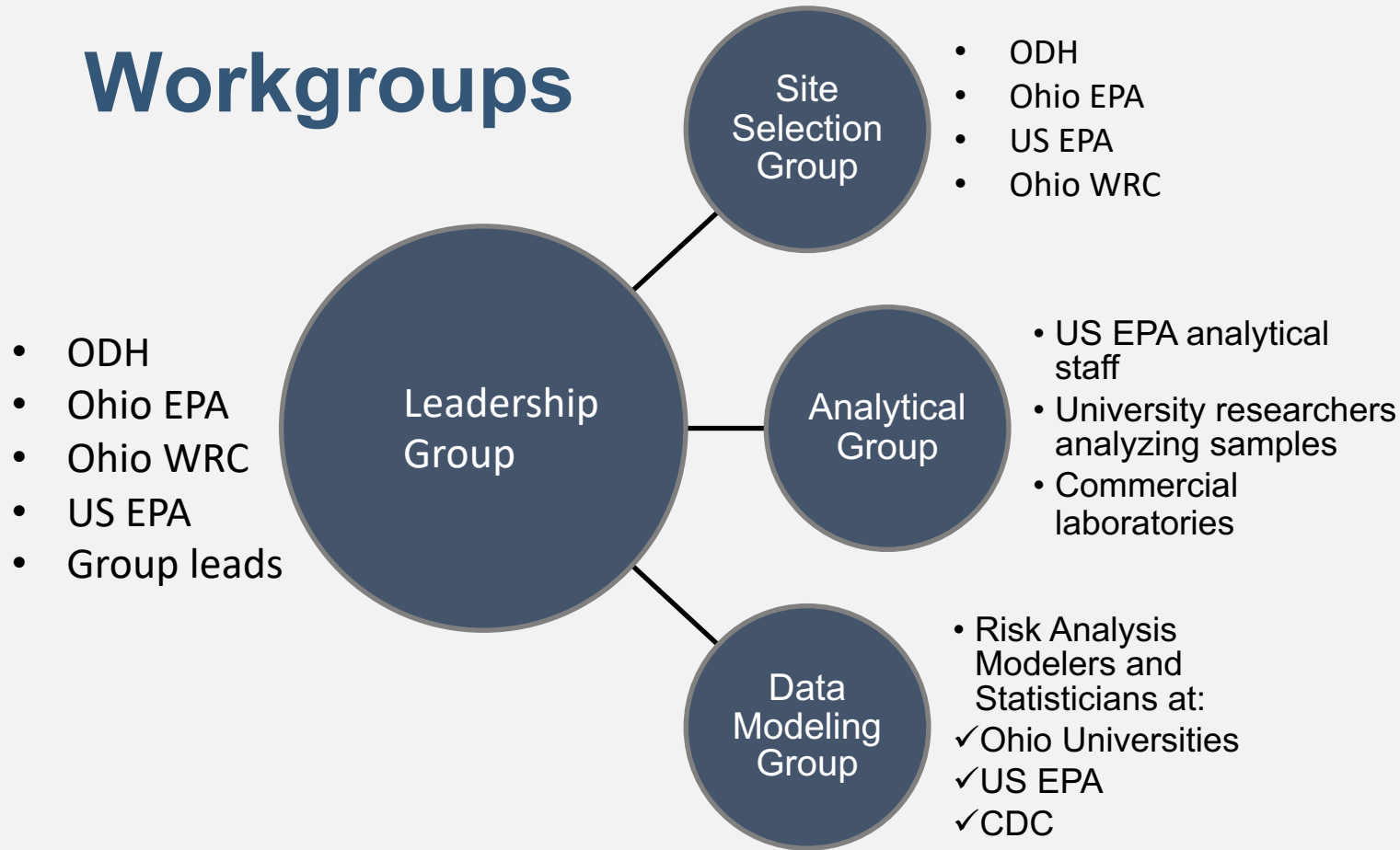
Adding Sites
August – October 2020

- Medium and smaller cities
- 4 added laboratories – UA, KSU,
Commercial lab, BGSU
- Sampling frequency twice a week
- 21 sites and adding 25 other sites



Workgroups created
Part of CDC national
monitoring network
Working on analytical methods
Working on data analysis

Workgroups



Other Project Partners

- Ohio's Utilities
- Local Health Departments
- Municipalities
- OTCO, AOMWA, OWEA

Ohio Wastewater Monitoring Network - University Involvement

- **Zuzana Bohrerova**, Associate Director and Research Specialist, *Ohio Water Resources Center and OSU CEGE*
- **Linda Weavers**, co-Director and Professor, *Ohio Water Resources Center and OSU Civil, Environmental and Geodetic Engineering*
- **John Lenhart**, co-Director and Professor, *Ohio Water Resources Center and OSU Civil, Environmental and Geodetic Engineering*
- **Mark Weir**, Assistant Professor, *OSU College of Public Health (COPH) – Environmental Health and Safety*,
- **Jiyoung Lee**, Professor, *OSU COPH – Environmental Health and Safety*
- **Stan Lemeshow**, Professor, *OSU COPH - Biostatistics*
- **Dae-Wook Kang**, Assistant Professor, *University of Toledo, Civil and Environmental Engineering*
- **Travis Taylor**, Assistant Professor, *UT, Medical Microbiology and Immunology*
- **Saurabh Chattopadhyay**, Assistant professor, *UT, Medical Microbiology and Immunology*
- **Xiaozhen (Jen) Mou**, Associate Professor, *Kent State University, Biological Sciences*
- **Stephen Duirk**, Associate Professor, *University of Akron, Environmental Engineering*
- **John Senko**, Associate Professor, *University of Akron, Geosciences*
- **Timothy Davis**, Professor, *Bowling Green State University, Life Sciences*
- **Natalie Hull**, Assistant Professor, *Ohio State University, CEGE*

Weekly Schedule

Sample

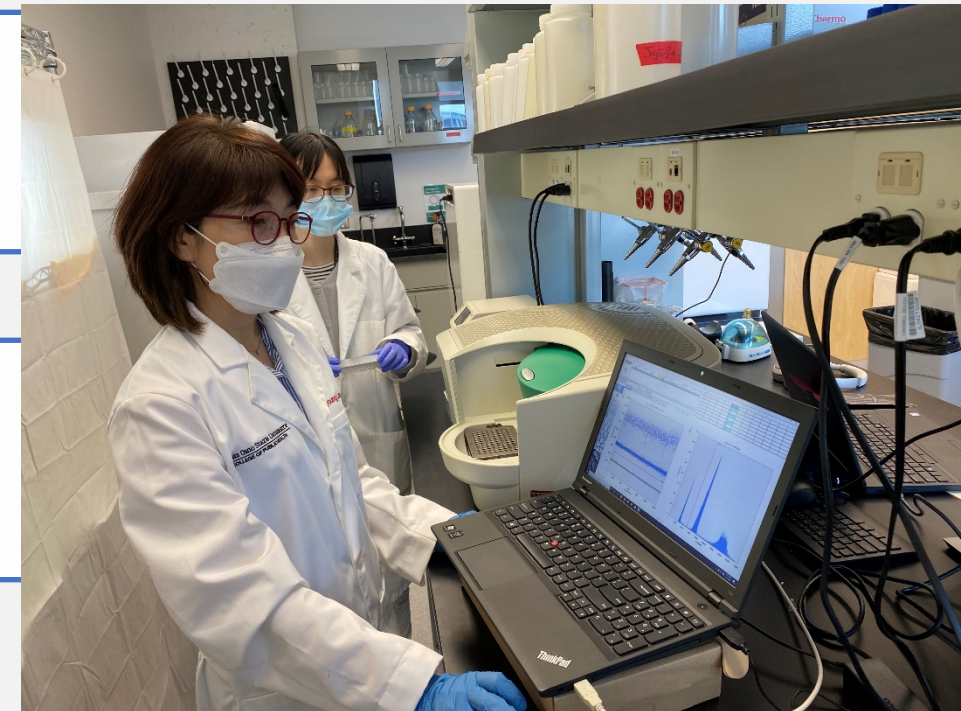
- Utility collects influent sample twice a week
- 24-hour composite sample, flow, WW temperature, pH and TSS if measured
- Sent to or picked up by designated lab

Analysis

- 6 analytical laboratories
- Methods vary
- 3 – 4 days turn around time

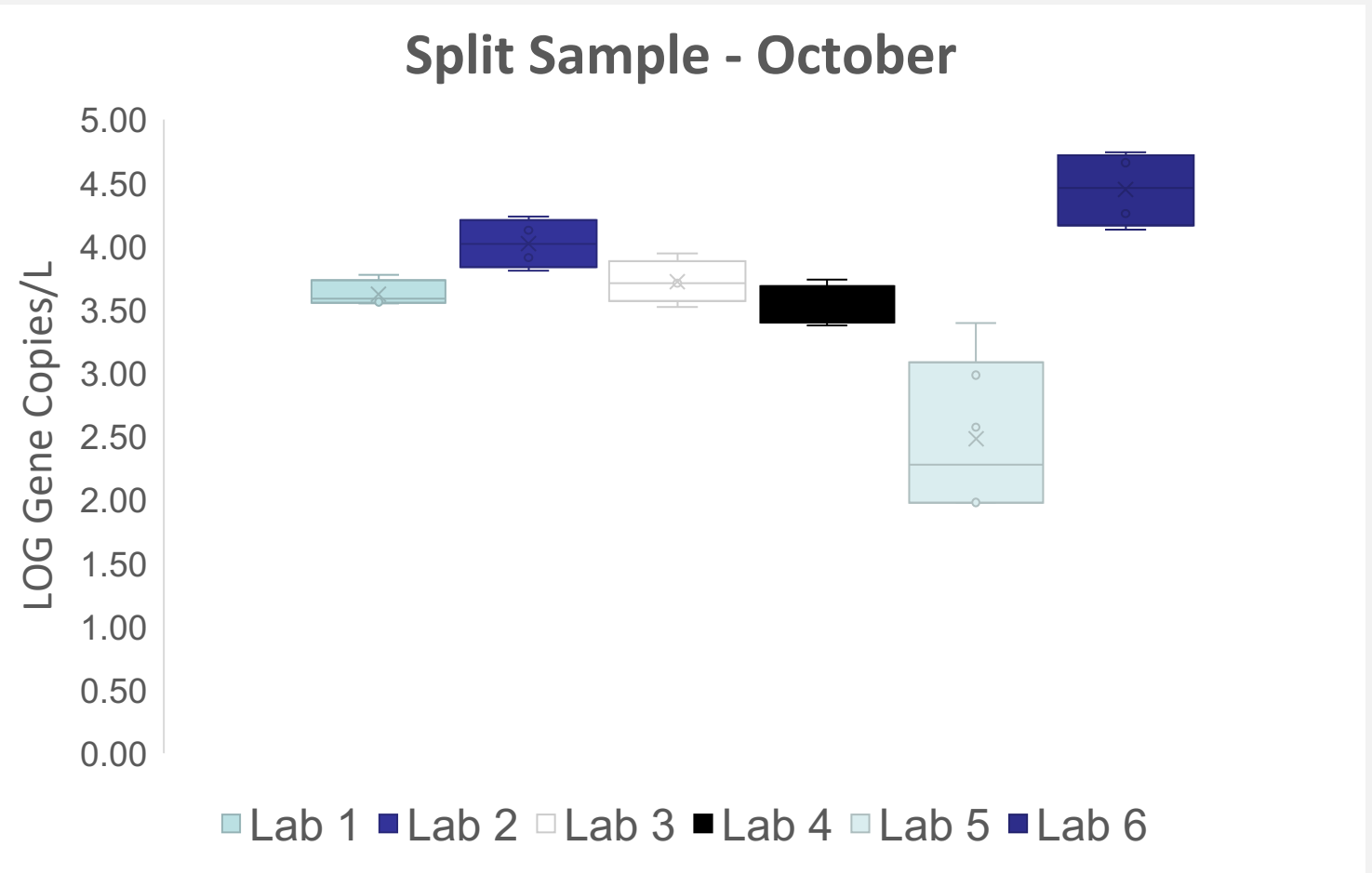
Results

- Compiled by Ohio WRC
- Threshold analysis still in progress
- Transferred to ODH for display on dashboard



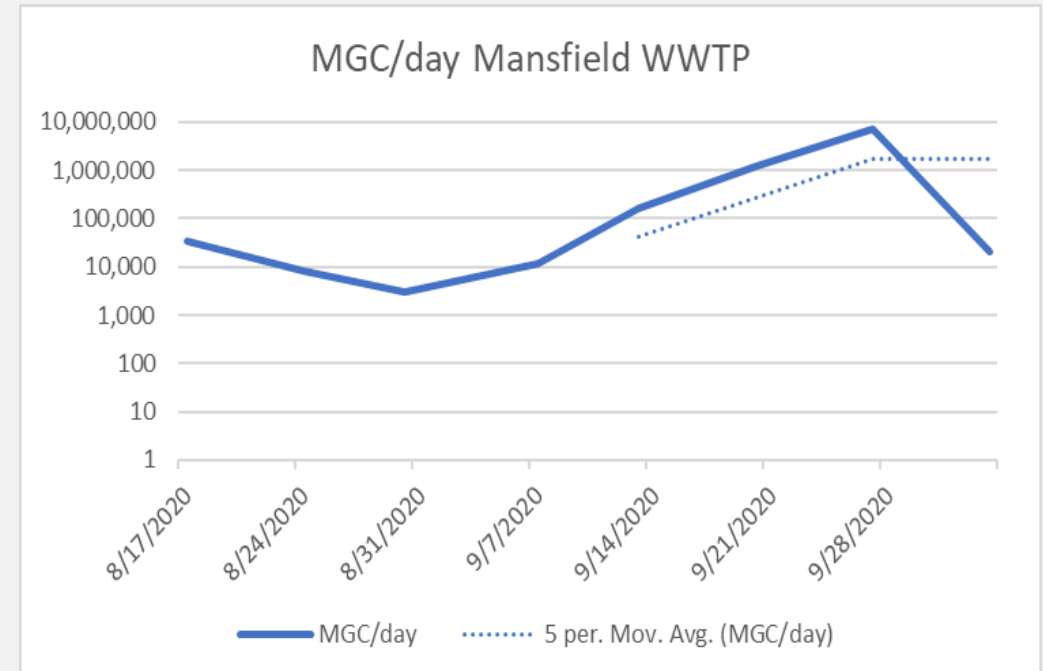
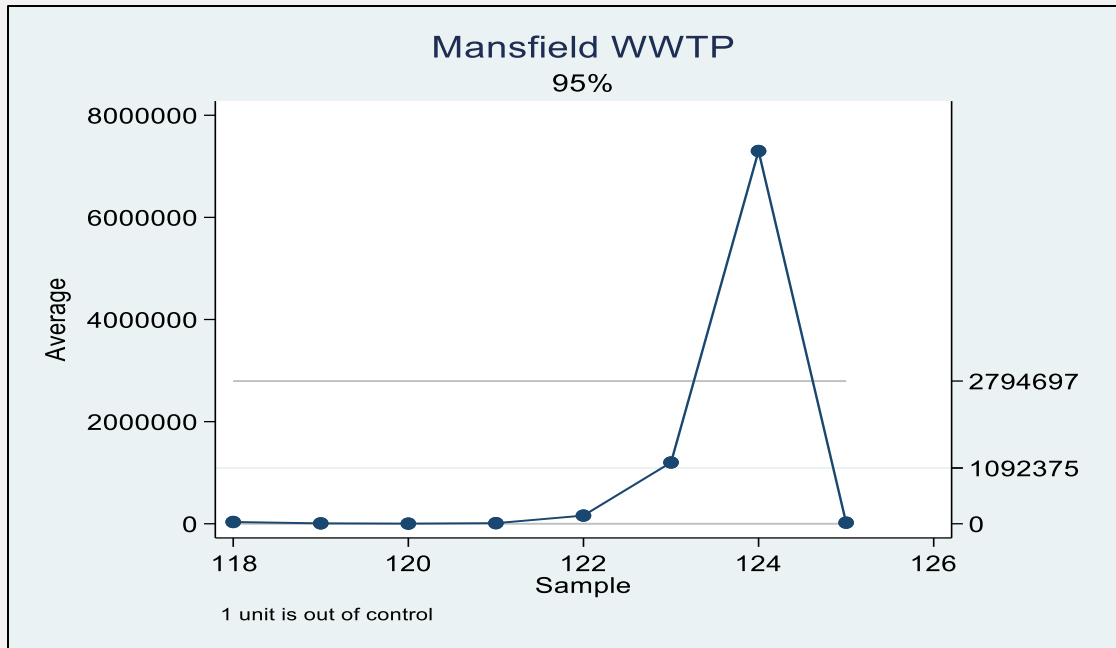
Interlaboratory Comparisons

- Once a month
- SARS-CoV-2 positive sample send to all the labs
- Normal protocols performed
- Results analyzed



Data Analysis

- Statistical analysis
 - Threshold values that warrant community notification
 - Longer term trends
- Modelling



Rebecca Fugitt | Contact: Rebecca.Fugitt@odh.ohio.gov

Rebecca Fugitt is the Assistant Chief of the Bureau of Environmental Health and Radiation Protection at the Ohio Department of Health where she oversees programs related to residential water and sewage, harmful algal blooms, fish consumption advisories and health assessment, Legionella, radioactive materials licensing, X-ray registration and inspection, and radiation health and safety. She holds a B.S. and M.S. degrees in Geological Sciences from Ohio University and is a registered sanitarian in the state of Ohio. She was the program manager for the Residential Water and Sewage program at ODH for 19 years, and program manager for the Water Resources Section at the Ohio Department of Natural Resources for 11 years. Prior to joining the state, Rebecca served as a research hydrogeologist for the National Ground Water Association.



Application – State of Ohio Effort

Governor DeWine asked what it would take to develop a state-based wastewater effort on Memorial Day, 2020

- Ohio applied for and received \$2 million in CARES funding to develop a statewide wastewater monitoring network in Ohio to monitor for coronavirus gene copies/fragments
- This network is a coordinated effort between the Ohio Water Resources Center (Ohio State University), the US EPA - Office of Research and Development in Cincinnati, and partnering university laboratories including Ohio State University, University of Toledo, Kent State University and University of Akron.
- The purpose of the effort is to monitor the trends in the number of gene copies as a leading indicator of disease occurrence in a community, to help understand disease trends, prioritize resources and to inform community interventions to limit the spread of disease.

Ohio Wastewater Monitoring Network

Ohio EPA, ODH, Ohio Water Resource Center (in coordination with state university system researchers) worked to implement the statewide network

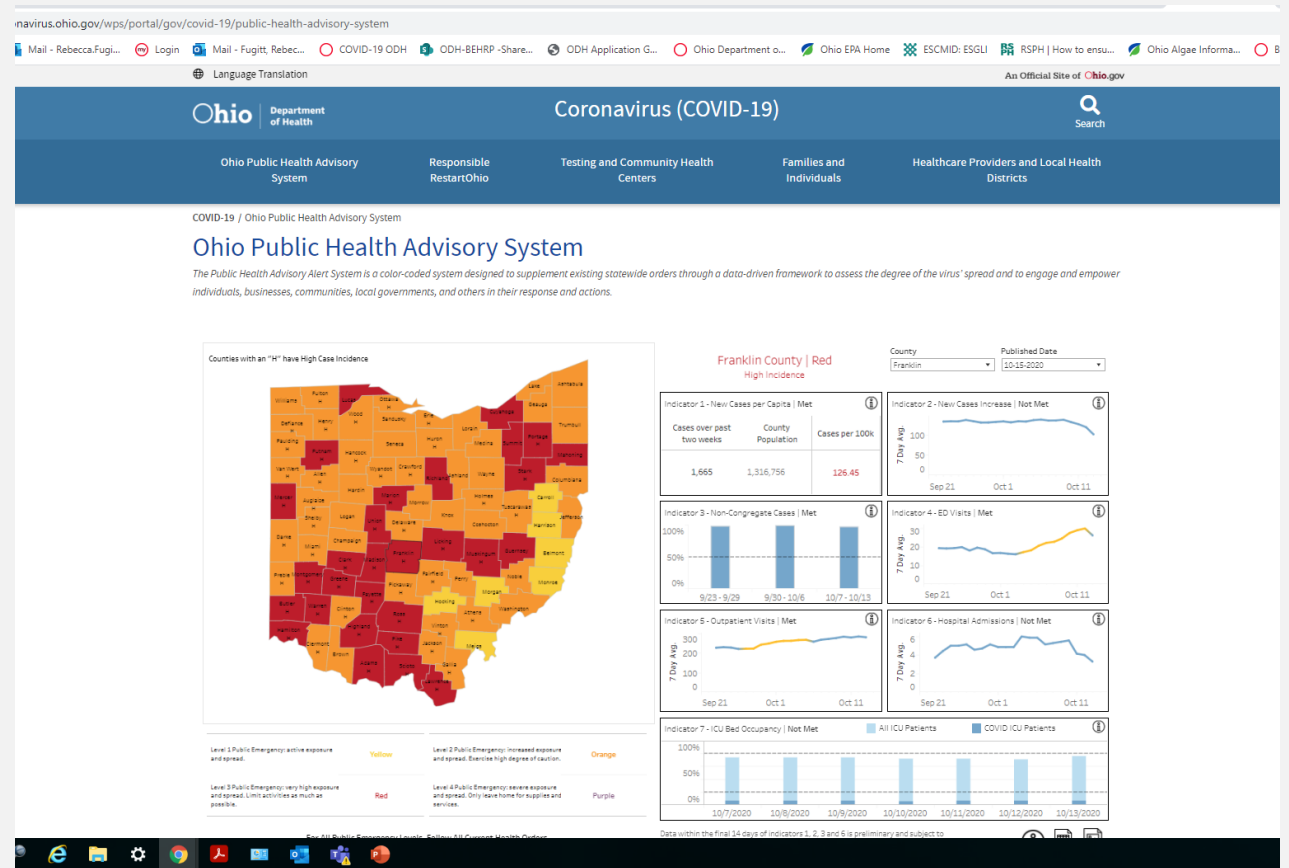
Initial sites were chosen with a focus on **7 major metropolitan areas** (Cleveland, Columbus, Cincinnati, Dayton, Toledo, Akron, Youngstown)

- These areas represent large percentage of state population
- Had initial higher rates of cases
- Includes some municipalities with multiple wastewater treatment plants

Ohio Wastewater Monitoring Network

Additional medium and small cities were then added to the network based on:

- Current status in the Ohio Public Health Advisory System
- Interest from the community to participate
- Availability of autosamplers and infrastructure for sample collection
- Vulnerability assessment information



Ohio Wastewater Monitoring Network

Network Status

- Initial sampling was once weekly at sites – now expanded to twice weekly sampling based on CDC recommendations
- Currently monitoring at 52 sites
- Goal is to add about 20 additional sites to the network over the next month
- All data collected from university networks, commercial lab and US EPA are entered into one database for upload to state Innovate Ohio Platform (IOP).
- Viral gene copy results are presented on a dashboard on the Coronavirus website that can be easily used by communities to understand disease trends and inform intervention actions to help prevent further disease occurrence.

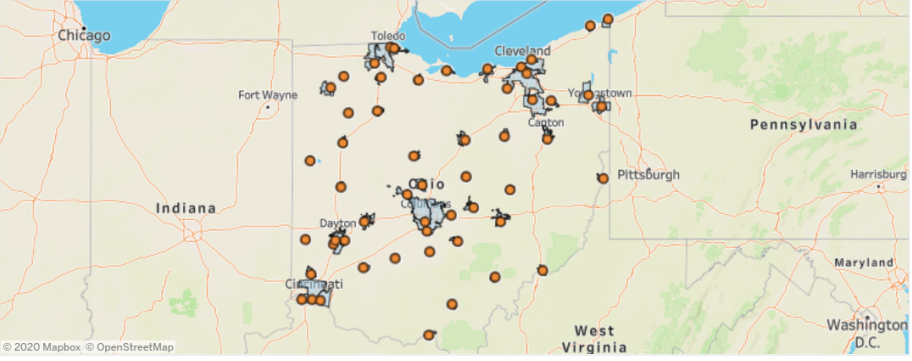
Language Translation

Ohio | Department of Health

Coronavirus (COVID-19)

Ohio Public Health Advisory System Responsible RestartOhio Testing and Community Health Centers Families and Individuals Healthcare Providers and Local Health Districts

Wastewater Treatment Plant Locations and Boundaries



Click a site to zoom in and view data for that site. To return to the state view, click the site again.
When viewing on a mobile device, such as a phone or tablet, pinch with both fingers to move the map or zoom in on a specific area.

Last updated: 11-01-2020

GoToWebinar Ope...exe ODH_Dashboard (3).csv Site_Information (4).csv GoToWebinar Ope...exe

<https://coronavirus.ohio.gov/wps/portal/gov/covid-19/dashboards/wastewater>

Language Translation

Ohio | Department of Health

Coronavirus (COVID-19)

Ohio Public Health Advisory System Responsible RestartOhio Testing and Community Health Centers Families and Individuals Healthcare Providers and Local Health Districts

Overview Current Trends Key Metrics Schools and Children Long-Term Care Facilities Demographics **Wastewater Monitoring Network** Other Resources

Ohio Coronavirus Wastewater Monitoring Network

In a new effort to help mitigate the spread of COVID-19, a network across Ohio is studying samples of wastewater to look for the presence of gene copies/fragments of the virus that causes the disease.

Ohio | Department of Health Ohio Environmental Protection Agency Ohio Water Resources Center

What Is the Ohio Coronavirus Wastewater Monitoring Network?

In a new effort to help mitigate the spread of COVID-19, a network across Ohio is studying samples of wastewater to look for the presence of gene copies/fragments of the virus that causes the disease. The initiative is a collaboration between the Ohio Department of Health (ODH), the Ohio Environmental Protection Agency (Ohio EPA), the U.S. Environmental Protection Agency (U.S. EPA), the Ohio Water Resources Center (Ohio WRC) at The Ohio State University, and other participating universities, including The University of Toledo, Kent State University, and The University of Akron. As the network expands, sampling and analysis will include other universities with laboratory capabilities.

Map Viewing Tips

Click a site to zoom in and view data for that site. To return to the state view, click the site again. When viewing on a mobile device, such as a phone or tablet, pinch with both fingers to move the map or zoom in on a specific area.

Note: A full screen option for this dashboard can be found on the lower right corner. To exit full screen mode press the 'Esc' key.

oWebinar Ope...exe ODH_Dashboard (3).csv Site_Information (4).csv GoToWebinar Ope...exe

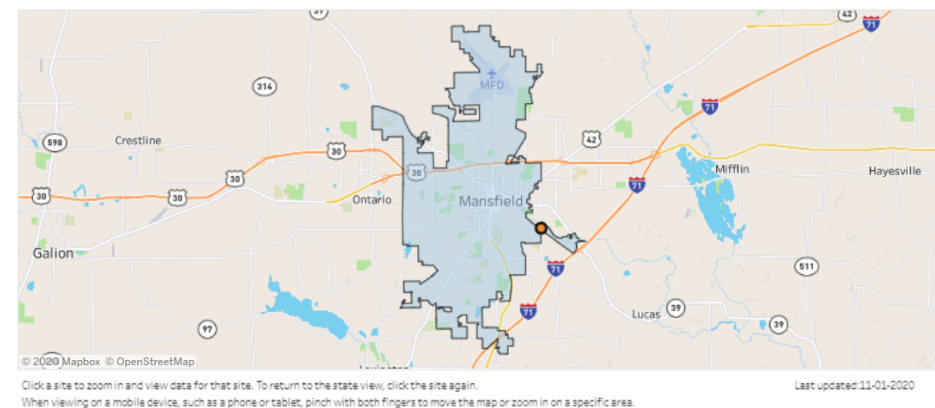
Language Translation

Ohio | Department of Health

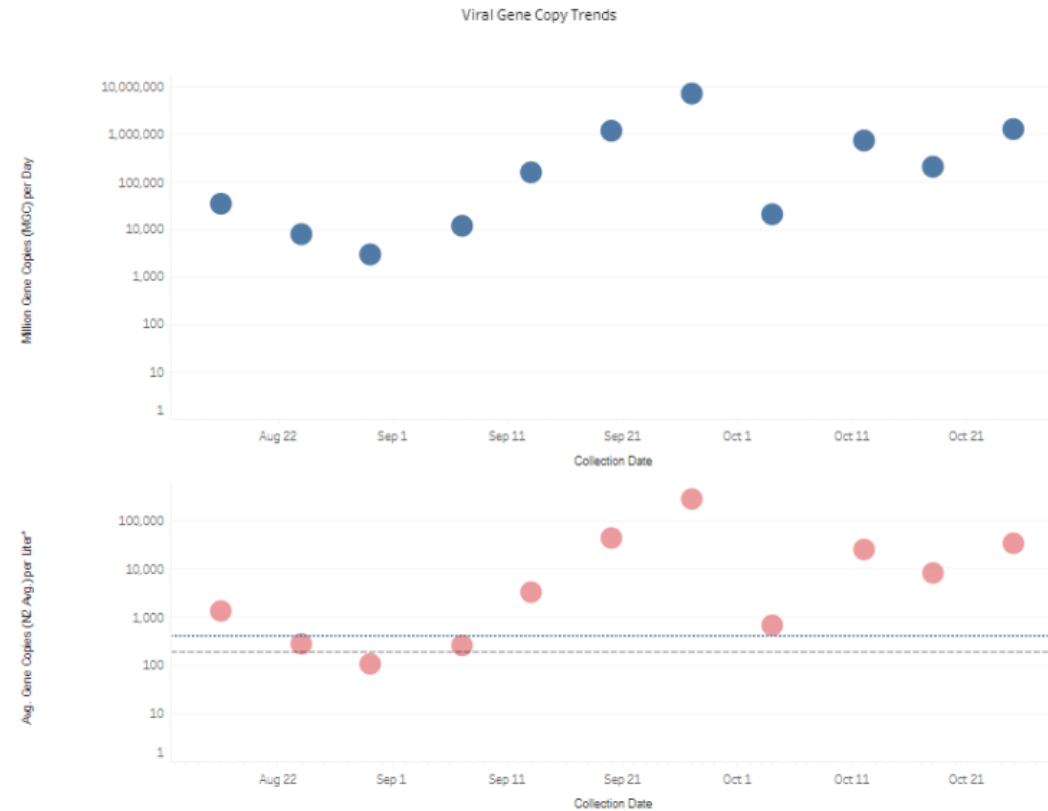
Coronavirus (COVID-19)

Ohio Public Health Advisory System Responsible RestartOhio Testing and Community Health Centers Families and Individuals Healthcare Providers and Local Health Districts

Wastewater Treatment Plant Locations and Boundaries



Facility Name = Mansfield WWTP



*Limit of Quantification (LOQ): Results below this limit are low and, while detectable, cannot be accurately counted. These are therefore referred to as being below the limit of quantification.
Limit of Detection (LOD): Results below this limit are too low for the instrument to detect, referred to as being below limit of detection. This does not mean there is no virus in the community.

[Download the data \(CSV\)](#)[Download the data term definitions \(CSV or PDF\)](#)[Download information on collection sites \(CSV\)](#)

Why Is This Being Done?

<https://coronavirus.ohio.gov/wps/portal/gov/covid-19/dashboards/wastewater>

AutoSave Off

File Home Insert Draw Page Layout Formulas Data Review View Help

Clipboard

Font

Alignment

Number

Styles

Cells

Editing

Ideas

Sensitivity

Search

Share

Comments

Site Information (2) - Excel

Fugitt, Rebecca FR

Official Site of Ohio.gov

Search

and Local Health

Facility_ID	Site_ID	Facility_N	Site_Mun	Site_County
4PF00000	4PF00000	Jackson Pi	Columbus	Franklin
4PF00001	4PF00001	Southerly	Columbus	Franklin
2PF00000	2PF00000	Toledo Ba	Toledo	Lucas
3PE00001	3PE00001	NEORS V	Cleveland	Cuyahoga
3PF00001	3PF00001	NEORS E	Cleveland	Cuyahoga
3PF00002	3PF00002	NEORS S	Cleveland	Cuyahoga
1PM00001	1PM00001	Mill Creek	Cincinnati	Hamilton
1PL00000	1PL00000	Little Mia	Cincinnati	Hamilton
1PK00006	1PK00006	Muddy Cr	Cincinnati	Hamilton
2PD00035	2PD00035	Oregon W	Toledo	Lucas
3PE00006	3PE00006	Youngstov	Youngstov	Mahoning
3PF00000	3PF00000	Akron WP	Akron	Summit
1PL00001	1PL00001	Eastern R	Dayton	Montgomery
1PL00002	1PL00002	Western F	Dayton	Montgomery
1PF00000	1PF00000	Dayton W	Dayton	Montgomery
2PD00011	2PD00011	City of Ma	Marion	Marion
4PE00001	4PE00001	Newark W	Newark	Licking
4PE00002	4PE00002	Marysville	Marysville	Union
4PD00004	4PD00004	Upper Ole	Delaware	Delaware
4PD00001	4PD00001	Lancaster	Lancaster	Fairfield
0PD00000	0PD00000	Athens W	Athens	Athens
2PF00001	2PF00001	City Of Sa	Sandusky	Erie
2PE00001	2PE00001	Mansfield	Mansfield	Richland
2PD00033	2PD00033	Celina W	Celina	Mercer

Site Information (2)

this early warn

Where Is This

The sewage m

will be expand

How Does It Work

Sample_ID	Site_ID	Facility_N	Collection_Date	Flowrate_Sample	Flowrate_N2_Avg	Load_N2_Avg	Data_qualifier
4PF00000	4PF00000	Jackson Pi	7/19/2020	63400000	2.4E+08	785.25	1.88456E+11
4PF00001	4PF00001	Southerly	7/19/2020	76070000	2.88E+08	1014.75	2.92204E+11
1PM00001	1PM00001	Mill Creek	7/26/2020	71000000	2.69E+08	877.6301483	2.35876E+11
1PL00000	1PL00000	Little Mia	7/26/2020	28620000	1.08E+08	308.2810293	33398699750
1PK00006	1PK00006	Muddy Cr	7/26/2020	86550000	32762739	1078.408641	35331620818
2PF00000	2PF00000	Toledo Ba	7/26/2020	39000000	1.48E+08	3350	4.94564E+11
2PD00035	2PD00035	Oregon W	7/26/2020	39000000	14763106	14000	2.06683E+11
3PE00001	3PE00001	NEORS V	7/26/2020	11000000	41639530	277.5	11554969471
3PF00001	3PF00001	NEORS E	7/26/2020	52000000	1.97E+08	361	71059750009
3PF00002	3PF00002	NEORS S	7/26/2020	86500000	3.27E+08	5751.5	1.88326E+12
4PF00000	4PF00000	Jackson Pi	7/26/2020	66000000	2.5E+08	316.5	79073466756
4PF00001	4PF00001	Southerly	7/26/2020	76700000	2.9E+08	436.75	1.26806E+11
2PF00000	2PF00000	Toledo Ba	8/2/2020	52500000	1.99E+08	9433.5	1.87476E+12
2PD00035	2PD00035	Oregon W	8/2/2020	51000000	19305600	2860	55214016281
4PF00000	4PF00000	Jackson Pi	8/2/2020	72400000	2.74E+08	1469.75	4.02805E+11
4PF00001	4PF00001	Southerly	8/2/2020	102400000	3.88E+08	1283.25	4.97421E+11
2PD00011	2PD00011	City of Ma	7/29/2020	10900000	41260988	648.6556643	26764173869
1PL00001	1PL00001	Eastern R	8/3/2020	81580000	30881389	485.8295477	15003091414
1PL00002	1PL00002	Western F	8/3/2020	109650000	41507040	541.7142557	22484955396
1PF00000	1PF00000	Dayton W	8/3/2020	42320000	1.6E+08	647.7548046	1.03769E+11
3PE00001	3PE00001	NEORS V	8/2/2020	33400000	1.26E+08	1267.5	1.60254E+11
3PF00001	3PF00001	NEORS E	8/2/2020	114200000	4.32E+08	1497.5	6.4736E+11
3PF00002	3PF00002	NEORS S	8/2/2020	168810000	6.39E+08	2730.833333	1.74504E+12
1PM00001	1PM00001	Mill Creek	8/2/2020	144580000	5.47E+08	1153.929978	6.3154E+11

Public Health Applications

- The focus is on **trends or significant changes** in the number of viral gene copies detected.
- ODH and WRC are monitoring trends
- Currently action is taken when at least 3 samples show a sustained increase of at least 10-fold (1 log)
- State actions when increases are observed:
 - Notify the local health district and utility
 - Provide information on how to interpret the data and link to message toolkit
 - Notify the state pandemic testing team for linkages to establish pop-up testing sites and the state contact tracing team to offer assistance
 - Provide case data by watershed to local health district (this extraction to be provided soon)

Public Health Applications

Development of toolkit for local health districts and utilities:

- Additional messaging to public on best practices – social media, twitter
- Sample press release
- Provision of FAQs

Also requesting local health districts to:

- Implement messaging to the public
- Consider mobilizing additional testing or PPE if necessary
- Alert hospitals, physicians, other health care providers
- Closely monitor & evaluate data, (hot spots, contact tracing)
- Provide recommendations to local leaders to take direct actions

Toolkit link: <https://coronavirus.ohio.gov/wps/portal/gov/covid-19/healthcare-providers-and-local-health-districts/for-local-health-districts-and-governments>

Future Public Health Applications

- Develop methodologies/predictive models to translate viral loads detected for comparison to health surveillance data or percentage of infection in communities.
- Predict or compare results to the prevalence data study for specific communities to better understand factors affecting disease spread.
- Determine impacts on disproportionately affected communities (blue-collar, ethnic, race) where risk of infection is greater.
- Coordination with data used in the Ohio Public Health Advisory System

Final Summary

- Sewer signal can detect moderate levels of rising infections
- Continued efforts to improve approach
 - Increasing recovery efficiency is a priority
 - Improving predictive capability of relating the sewer signal to infection rates
 - Refine normalization approaches
 - Directly relate wastewater to sewershed infection rates
- On-going, collaborative evaluation of the value of the wastewater signal to inform public health
 - Sewershed (i.e., treatment plant) scale and potentially more granular
 - Defining threshold or trigger points for decision making
- What happens after the pandemic?

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